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SWITCHABLE ZERO ORDER DIFFRACTION GRATINGS AS LIGHT  
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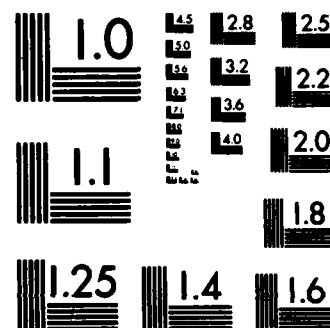
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Semiannual Report

Switchable Zero Order Diffraction

Gratings as Light Valves

Office of Naval Research

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## Introduction

The motivation of this work is to produce line-addressable arrays of independently switchable light valves for flat-panel video displays. In addition, such light valves would be useful as spatial light modulators in optical signal processing. The principle of the light valves is based on the switching of the zero order of diffraction. Two gratings are fabricated face-to-face and displaced with respect to one another by half of one period. The displacement may be produced by using the strong piezoelectric properties of  $\text{PVF}_2$  or, alternatively, by using electrostatic forces. The goal of this project is to build a fast, lockable, miniature light valve which is compatible with fabrication into arrays.

## Progress

### A. Fabrication of Gratings:

Gratings of  $3.4\mu\text{m}$  period have been produced by holographic lithography. Such gratings are free of the patch-work effect which occurs in pattern generator produced gratings due to stitching error. The gratings have been transferred to nickel by plating techniques and embossed into  $\text{PVF}_2$ . Some strain recovery was found to occur after the embossing, and we needed to study the temperature and pressure dependence of the embossing process. The best operating parameters have been identified. Gratings in  $\text{PVF}_2$  have thus been fabricated which, when put face to face, have the desired optical properties. Gratings were also fabricated in quartz by reactive ion etching, and their optical properties in the bigrate configuration (face to face) have been measured.

## B. Production of Micromotion in PVF<sub>2</sub>

Techniques for metallizing PVF<sub>2</sub>, which is poled so that an electric field perpendicular to the surface will cause the surface to shrink laterally, have been developed, the expected motion has been observed, and the piezoelectric coefficient has been measured. Two such sheets of PVF<sub>2</sub> were glued face to face to form a bimorph. (Much like a bimetallic strip.) This in effect amplifies the amount of motion obtained per applied potential. The bimorph also behaved as expected. Designs for a light valve using the bimorph were examined, and a simple structure to test the concept is being built. However, a design, which uses patterned PVF<sub>2</sub> with angled strips providing the motion, appeared to be simpler and is also being pursued. The patterning of the PVF<sub>2</sub> will need to be done using reactive ion etching in oxygen. The techniques for mounting the sample during etch have been developed. The etch rate has been found to be 0.1 $\mu$ m/min.

## C. Production of Micromotion Using Electrostatic Forces

In a configuration of facing but electrically insulated interdigitated electrodes the achievable electrostatic forces were calculated to be large enough to produce the desired motion. A test structure was built entirely of quartz with 2 $\mu$ m electrodes separated by 2.5 $\mu$ m gaps. No lateral displacement of the two surfaces of quartz relative to each other was observed up to the limit of the voltages used. Some clamping action of one surface with respect to another, which is also a necessary ingredient of the light valve, could be produced by flat relatively large electrodes.

Masks have been designed and fabricated with 4 $\mu$ m and 6 $\mu$ m gap between the electrodes. These structures are being built on quartz, and the moveable part was built on mylar.

## Conclusions

At this point in the research program we have perfected the techniques for embossing ratings in PVF<sub>2</sub>, demonstrated the optical principles of the bigrate, chosen a design for a single element, developed methods of reactive ion etching the PVF<sub>2</sub>, and fabricated structures to test the electrostatic motion. We have narrowed our goal to building a single miniature light valve that is capable to being fabricated into arrays and have laid the ground work for achieving the goal.

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